PROBLEMS OF AUTOMATION AND MECHANIZATION

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OPTIMIZATION OF GLASS BATCH PREPARATION

V. V. Efremenkov[1] and V. P. Chalov[1]

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An optimum cyclogram for dosing small additives in glass batch preparation is considered, taking into account indirect control of mixing quality based on the mixer motor power. A scheme of preparation and introduction of a premix of selenium and cobalt oxide with a filler is described.

The processes of preparation of raw materials and their mixing to obtain a homogeneous batch are important stages in the production of glass and glass articles. Deviations in the chemical and granulometric composition of the glass batch, decreased dosing accuracy, and errors in the mixing and moistening cyclogram generate defects in the glass and impair product quality.

Significant factors affecting glass batch quality are the sequence of feeding the material components into the mixer and the duration of mixing. For various types of mixers, mixing lasts 2.5 – 4 min and its duration is determined by the mixing-unit efficiency, the chemicomechanical properties of the initial materials, and the sequence of charging and moistening sand and clotting components of the glass batch. According to the standard method, the optimum batch preparation cyclogram envisions charging of sand to a mixer and its moistening and then (after moistening) successive feeding of soda and other clotting materials [1] and small additives whose content in the formula constitutes fractions of a percent (coal, glass-batch pigments, etc.). Pegmatite and feldspar can be fed into the mixer simultaneously with the sand.

Charging soda on top of sand moistened in the mixer allows for better batch mixing and prevents clotting. The quality of mixing and mixture homogeneity can be monitored indirectly from the load of the electric motor rotating the agitator blades (RF patent No. 2115632) [2]. The power consumed by the electric motor is measured by a current transformer, whose signal is sent to the analog input of a microprocessing controller, which controls the operation of the weighing-and-mixing line. At the same time, this signal makes it possible to record the loaded state of the mixer and, in the case of a program failure, stops feeding the second portion into the mixer. Although the power consumed by the mixer motor depends on a number of random factors that are virtually impossible to measure (wear of the agitator blades, network voltage fluctuations, material sticking to the mixer walls and blades, etc.), this method makes it possible to estimate the relative fluctuations in power, regardless of its absolute value.

The sequence and duration of the operations in glass batch preparation, taking into account monitoring of the power consumed by the mixer drive, are shown in a cyclogram (Fig. 1).

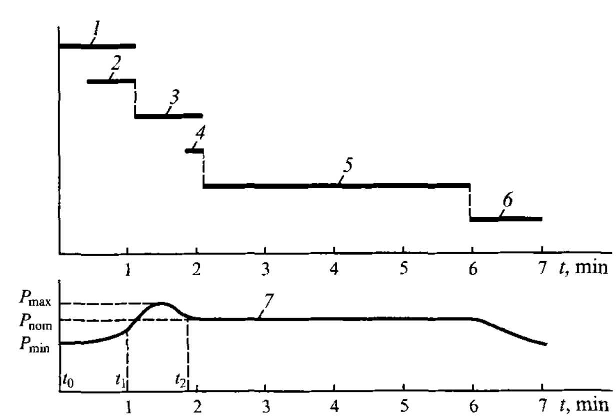

Fig. 1. Optimized cyclogram of glass batch preparation: *1*) feeding of sand into the mixer; *2*) sand moistening; *3*) feeding of soda and other components into the mixer; *4*) feeding of small additives; *5*) batch mixing; *6*) batch discharge from the mixer; *7*) power consumed by the mixer electric motor.

[1] BSPKTO Stekloavtomatika JSC, Russia.

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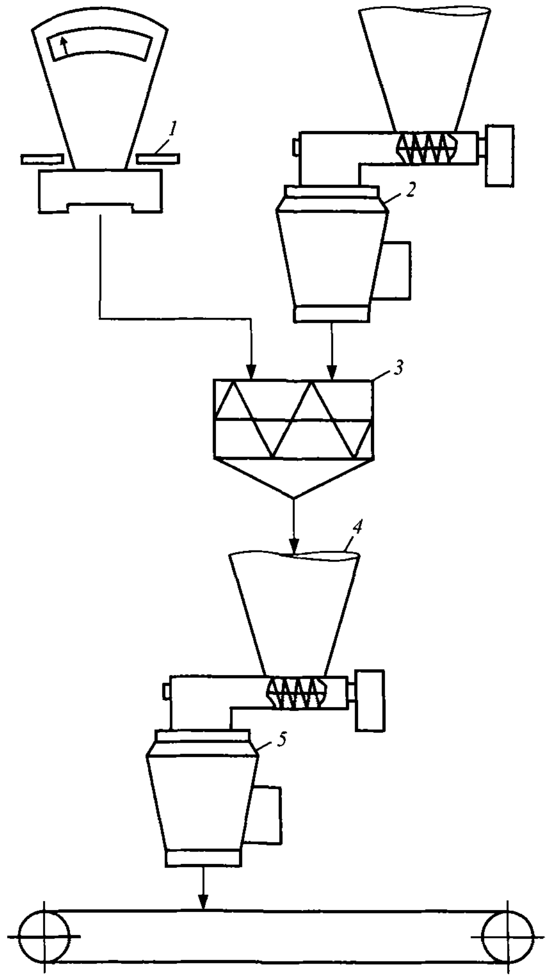

Fig. 2. System of premix preparation.

With the mixer connected and empty (moment of time t_0), the power consumed by the drive has the minimum value $P_{\min}$. After discharging sand and feeding water into the mixer, the electric-motor power spent on blade rotation increases and reaches its maximum value $P_{\max}$ during the charging of soda and other material components. This ensues from the fact that in the initial contact of clotting components with moistened sand the resistance of the agitator blades increased. In the time interval $t_1 - t_2$ the mixture is inhomogeneous and consists of alternating layers of moistened sand and other components partly mixed with sand and with each other. It is inadvisable to feed small additives in that period, since they may enter one of the inhomogeneous layers and subsequently fail to be distributed uniformly over the whole volume of the mixer.

By the time 75 – 90% soda and other batch components are charged, the batch becomes more homogeneous and mobile, and the power consumed by the motor decreases to the rated value P_{nom}. This is the moment when it is necessary to start feeding small additives, since they will be more uniformly distributed in partly mixed moistened sand and other materials.

The required mobility of the mixture, characterized by the consumed motor power P_{nom}, may be achieved before 75 – 90% glass batch components are loaded. This becomes possible if the feed of the clotting materials to the mixer is delayed (material stuck in the weigher, a short-time emergency stop, etc.). Therefore, it is important to record P_{nom} in the final stage of feeding soda and other materials. Feeding small additives in this stage does not extend the batch preparation cycle, since their feeding duration is shorter than that of 10 – 25% soda.

The overall count of the mixing duration starts from the moment when all weighers are emptied and ends not more than 4 min later by opening the mixer gate. Excessive mixing time can degrade the batch quality due to the possibility of stratification and undesirable reactions among the batch components.

In order to ensure dosed feeding of such small additives as selenium and cobalt oxide, which act as decolorizing additives in the production of clear glass containers, it is necessary to prepare a so-called premix. The estimated content of decolorizing additives in a batch is 1.4 – 1.7 g Se and 0.07 – 0.08 g CoO per 100 kg of glass melt. Automated dosing of these materials in such small quantities using currently available weighers entails substantial relative errors. In practice these components are usually weighed in a laboratory and fed manually into the mixer either in a pure form or as a premix.

The probability of homogeneous distribution of small additives in a batch of 1000 – 1500 liter in direct feeding of them into the mixer is smaller than in the case of multistage mixing of them; that is why selenium and CoO are mixed preliminarily with sand or soda. Since the daily consumption of Se and CoO in 150 – 200 ton of batch is only 2 – 3 kg and 100 – 150 g, respectively, these doses can be weighed and mixed manually, with subsequent feeding into the premix preparation system (Fig. 2).

The system contains a scale *1*, a weigher *2* for the filler (soda or sand), a premixer *3*, a hopper *4* with a shift (8 h) or daily (24 h) mixture reserve, and a mixture weigher *5*. Depending on the premixer capacity, a mixture of selenium and cobalt oxide with the filler can be prepared either once per shift or once per day. Based on that amount, the required quantity of small additives is fed by hand into the mixer *3*, and the filler is charged employing the tensometric weigher *2* following a signal given by the operator. After a prescribed mixing cycle, the prepared mixture is discharged into the storing hopper *4* and from there via the weigher *5* is automatically sent in single batches to an accumulating conveyer or directly into the batch mixer. The premix of selenium and cobalt oxide with the filler should be regarded as a small additive, and it is advisable to feed it into the batch mixer after partial mixing of soda and other clotting components with moistened sand.

In order to exclude the possibility of error and make the process fully automated, the scale can be replaced (thereby

increasing the cost of the system) with special dosing dispensers for Se and CoO with a maximum dosing limit of 0.05 – 2.00 kg and a quantization of 0.001 kg.

Such premixing plants and dosing devices for feeding small components are currently produced by the Tekhnéx (Ekaterinburg) and Stromizmeritel' (Nizhnii Novgorod) companies.

The use of an optimum algorithm for feeding small additives into the mixer using tensometric weighers and premixing systems makes it possible to significantly improve glass batch quality in the production of clear glass containers and other glass articles.

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